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# HUMAN FACTORS ASSOCIATED WITH PROFILE DESCENTS

## Introduction

This study was carried out in order to provide information relevant to problems associated with profile descents. The study had three objectives:

1. To examine critically pilot and controller problems associated with the conduct of profile descents

2. To attempt, where possible, to identify human and system factors associated with these problems

3. To provide sufficient documentation of problems to assist cognizant authorities in seeking solutions for these problems

The material for the study included all relevant reports submitted to the ASRS between January 1 and September 30, 1977.

## Background

During 1976, the FAA conducted an evaluation of several programs designed to minimize the amount of time spent by high-performance aircraft in and around terminal areas. Four goals were established for the study:

1. Increase safety by reducing exposure time between controlled and uncontrolled aircraft at lower altitudes in the vicinity of airports

2. Reduce aircraft noise in the vicinity of airports

3. Conserve aircraft fuel

4. Standardize ATC arrival procedures

In pursuit of these goals, profile descent procedures were designed and evaluated at several locations. A profile descent was defined as: "an unrestricted descent (except where level flight is required for speed adjustment) from cruising altitude or flight level to interception of a glide slope or to a minimum altitude specified for the initial or intermediate approach segment of a nonprecision approach ... (the profile descent) terminates at the approach gate where the glide slope or other appropriate minimum altitude is intercepted."

The evaluation of profile descent procedures revealed that significant fuel savings were possible. The opportunities to use the procedures were diminished, however, by complicating factors such as aircraft descending at different speeds, varying conceptions of the procedures by different operators, and lack of familiarity with the procedures by air traffic controllers (extracted from ref. 1).

Comments by controllers and operators led the FAA to publish standardized profile descent procedures in the hope of standardizing usage of the procedures (ref. 1). The first publication, containing profile descents for Denver, appeared in December, 1976. The Denver profiles were revised and profiles for Atlanta were added in February, 1977; subsequent revisions have included changes in the manner of presentation of the profile descent data and addition of procedures for Miami and the San Francisco areas. Chicago has implemented similar descent procedures, but without publishing charts; other areas are preparing procedures for implementation in the immediate future.

Reports received by ASRS have indicated that certain problems exist in connection with the implementation of these procedures. It is important to note that there is virtually no disagreement with the concept, which appears to offer important advantages with respect to noise, fuel economy, and exposure time at lower altitudes (three of the FAA's expressed goals). Critical comments have been confined to the areas of procedures, charts, and human factors.

## Approach

All ASRS reports dealing with profile descents and received between January 1 and September 30, 1977 were reviewed. Additional materials used for the study were the NOS and Jeppesen profile descent charts issued between December 2, 1976, and October 6, 1977, fact sheets issued by certain ATC facilities, and correspondence and memos relating to profile descents, copies of which were made available to ASRS by organizations within the aviation community.

A total of 59 relevant reports was submitted to ASRS during the 9-month period. Pilots submitted 39 and ATC controllers submitted 20. Sixteen reports were concerned with the Denver area, 38 were concerned with profile descents at Atlanta, and 5 were concerned with other areas or general problems. Forty-three reports described occurrences involving human errors and 16 reports described potential problems related to profile descent procedures. The sections that follow describe the occurrences in terms of outcomes, enabling and associated factors, and the concerns of those who submitted informational reports. Table 9, following this chapter, summarizes the classification of each occurrence in terms of outcome, enabling and associated factors, and other relevant data.

## Results

*Geographic locations*— The specific arrivals/profile descents discussed in those reports are listed in table 1. No clear preponderance of reports dealing with a specific procedure was observed, although the absence of reports involving the Denver BYSON approach is noteworthy.

*Pilot and controller errors*— Forty-three reports described errors or alleged errors by pilots and controllers: of these, 39 were errors by pilots (including two allegations of error not concurred in by the reporter). A breakdown of these errors is shown in table 2.

Thirty-three of 37 confirmed pilot errors involved altitude deviations. There was an almost even distribution of overshoots and undershoots, which together comprised about two-thirds of the errors. Deviations from profile heading usually occurred about ten miles from the DME arc at which

TABLE 1.– PROFILE DESCENT PROCEDURES CITED IN REPORTS

| Denver | | Atlanta | |
|---|---|---|---|
| Kiowa | 6 | Sinca[a] | 10 |
| Drako | 5 | LaGrange | 9 |
| Keann | 2 | Rome | 8 |
| Byson | 0 | Macey[b] | 7 |
| Unknown/ nonspecific | 3 | Unknown/ nonspecific | 4 |
| | — | | — |
| | 16 | | 38 |

[a]Original name Sinclair, changed on April 21, 1977.
[b]Original name Lanier, changed to Lanie on April 21, to Macey on June 16, 1977.

a turn was mandated by the procedures. Three of four controller errors involved a potential conflict with less than standard separation between aircraft.

*Factors associated with errors*– Each occurrence report was evaluated to determine whether it described human, machine, or system factors associated with and relevant to the occurrence. A complete listing of the factors isolated is shown in the appendix. Factors were classified as "enabling" or "associated" on the basis of the criteria described in previous reports (ref. 2). Enabling factors are summarized in table 3, associated factors in table 4.

*Situation reports*– A number of reports provided information regarding profile descent problems but did not describe specific occurrences. The subject matter of these 16 reports is described in table 5.

TABLE 2.– PILOT AND CONTROLLER ERRORS

| Type of error | Number of reports | |
|---|---|---|
| Pilot errors | | |
| Altitude deviations | | |
| Altitude overshoot | 14 | |
| Altitude overshoot (alleged) | 2 | |
| Altitude undershoot | 12 | |
| Altitude excursion | 6 | |
| Altitude misread, corrected before overshoot occurred | 1 | |
| | — | |
| | | 35 |
| Deviation from profile heading | | 4 |
| | | — |
| | | 39 |
| Controller errors | | |
| Less than standard separation | 3 | |
| Failure to hand-off aircraft | 1 | |
| | — | |
| | | 4 |
| | | — |
| | | 43 |

TABLE 3.– ENABLING FACTORS IN PROFILE DESCENT REPORTS

| Factor | Number of citations |
|---|---|
| Pilot | |
| Utilized wrong chart | 12 |
| Misread correct chart | 9 |
| Misunderstood clearance | 6 |
| Misunderstood clearance amendment | 4 |
| Received clearance late | 3 |
| Misunderstood rules or procedures | 1. |
| Misread aircraft instruments | 1 |
| Maintained inadequate descent rate | 1 |
| (Report indicates allegations were incorrect | 2) |
| Controller | |
| Misunderstood developing situation (training) | 1 |
| Did not require clearance acknowledgment | 1 |
| Did not transfer control of aircraft | 1 |
| Gave instructions not followed by aircraft | 1 |

TABLE 4.– ASSOCIATED FACTORS IN PROFILE DESCENT REPORTS

| Factor | Number of citations | |
|---|---|---|
| Human factors | | |
| High workload | 7 | |
| Distraction | 7 | |
| Training/unfamiliarity | 5 | |
| Misunderstanding of rules/procedures | 3 | |
| Fatigue | 1 | |
| Misread aircraft altimeter | 1 | |
| | — | 24 |
| Software factors | | |
| Chart complexity/clutter | 4 | |
| Procedural complexity/ambiguity | 4 | |
| | — | 8 |
| Aircraft factors | | |
| Clearance exceeding aircraft descent parameters in idle/clean configuration | 4 | |
| Aircraft system malfunction | 1 | |
| | — | 5 |
| Environmental factors | | |
| Thunderstorms in immediate area | 4 | |
| Turbulence | 2 | |
| Frequency congestion | 2 | |
| Communications problem, unspecified type | 1 | |
| | — | 9 |

TABLE 5.– SUBJECT MATTER OF INFORMATIONAL REPORTS

| Topic | Number of reports |
|---|---|
| Pilot reports | |
| Workload involved in profile descents | 6 |
| Ambiguities in profile descent procedures | 2 |
| Arrival/departure conflict | 1 |
| Refutation of alleged potential conflict | 1 |
| Controller reports | |
| Arrival/departure/enroute conflicts | 3 |
| Descent rates: effect on RDP readout | 1 |
| Phraseology problems | 1 |
| Problems during profile descents at ORD | 1 |

## Discussion

It is obvious that a majority (75%) of these reports involve human errors during the conduct of profile descents. How many were submitted in order to support a claim for waiver of disciplinary action is impossible to determine, although controller reports indicate that altitude "busts" during profile descents are comparatively common:

> Aircraft A was inbound on a profile descent for runway 27L from over Tiroe intersection. When the aircraft was approximately 20 miles southwest it descended out of 11,000 ft. There were departures climbing to 10,000 ft, but the closest one was 7 miles away. Since the profile descent procedure was started in Atlanta, this type of pilot deviation has been happening every day.
>
> * * *
>
> Aircraft A was on a profile descent to runway 9R from over Tiroe and was supposed to cross the 25 DME southwest at 8000 ft, but crossed it at 9100 ft . . . This is an ongoing problem that started when profile descent procedures were established in Atlanta . . . .
>
> * * *
>
> Aircraft A was cleared for a Macey runway 26 profile descent and should have crossed 25 DME northeast at 10,000 ft. A crossed 25 DME at 12,000. This deviation was . . . verified by the pilot . . . no evasive action was required. This situation is, and has been, an everyday occurrence since profile descents began in Atlanta. It has now reached the point where controllers will not report these violations; they are still occurring frequently despite numerous earlier reports. Pilot education is the only solution to this situation. It must be pointed out to the pilots that we are basing separation on their making these crossing restrictions. I have personally volunteered my own time to conduct pilot-controller forums . . . .

It is certainly possible to assume that these errors simply represent inattention, or a lack of precision; some have used the term "complacency" in connection with such errors.

It is instructive, however, to attempt to discover whether there are common threads in this fabric of error reports. Is it possible to discern problems that are common to many or all of them? Specifically, are there factors associated with these errors, the alleviation of which might make the errors less likely or of less potential gravity from a safety standpoint? The data in tables 3, 4, and 5 can be restructured to assist in this examination, as shown in table 6.

Five areas appear to warrant detailed examination on the basis of the grouping shown in table 6. Putting aside the human factors for a moment, the system factors, in order of frequency, are charts, clearances, procedures, and aircraft. Each will be discussed briefly.

*Profile descent charts*— These comments do not relate to charts prepared by the National Oceanic Survey (NOS): few air carrier pilots use NOS charts, and no specific comments were made about them. Twenty-five percent of the enabling and associated factors in this study related to

TABLE 6.– PROBLEMS ASSOCIATED WITH PROFILE DESCENTS

| Problem area | Table 3 | Table 4 | Table 5 |
|---|---|---|---|
| Profile descent charts | | | |
| Used wrong chart | 12 | | |
| Misread correct chart | 9 | | |
| Chart complexity/clutter | | 4 | |
| Profile descent clearances | | | |
| Clearance misunderstood | 6 | | |
| Clearance amendment misunderstood | 4 | | |
| Late clearance | 3 | | |
| Clearance phraseology problems | | | 1 |
| Nontransfer of aircraft control | 1 | | |
| No acknowledgment of clearance | 1 | | |
| Instructions not followed by aircraft | 1 | | |
| Profile descent rules/procedures | | | |
| Misunderstood rules/procedures | 1 | 3 | |
| Complexity or ambiguity of rules | | 4 | 2 |
| Arrival/departure conflicts | | | 4 |
| Aircraft operations in profile descents | | | |
| Inadequate descent rates | 1 | | |
| Descent rate effect on RDP readout | | | 1 |
| Clearance exceeds descent parameters | | 4 | |
| Human factors in profile descents | | | |
| Workload factors (pilot and controller) | | 7 | 6 |
| Distraction | | 7 | |
| Problems during profile descent test | | | 1 |
| Misread aircraft instruments | 1 | 1 | |
| Effect of aircraft malfunction | | 1 | |
| Fatigue | | 1 | |
| Training/unfamiliarity | 1 | 5 | |
| Effect of environmental factors | | 8 | |
| Communication problem | | 1 | |
| (Allegations, not supported) | (2) | | (1) |

arrival and profile descent charts, however; certain errors were associated with their use.

In these reports, the most frequent problem was a pilot's use of an incorrect altitude datum, taken in haste from the wrong one of two charts on a single page. Profile descents for opposite direction runways are ordinarily printed on the same plate to minimize the number of pages that must be carried. The problem with this is that limitations on the two descents may be similar, but not identical. In a recent survey (ref. 3), pilots indicated a strong dislike for the large number of extra plates which the profile descent program entails, yet it appears from these data that two plates on a page may also present a problem.

Several errors were due to misreading a datum from the correct chart. These errors, in the main, were of three types:

1. Reading (and then flying to) a minimum enroute altitude instead of crossing altitude

2. Misreading an altitude limitation

3. Misreading the DME distance for a fix and departing the profile course (usually early rather than late)

Situation (1) was reported in this series only once, but other data have made it clear that it has happened a number of times (refs. 3 and 4). Situation (2) was reported several times, and occasioned an examination of a number of current (October 6, 1977) profile descent charts to determine the number and types of altitude limitations used in different areas. Table 7 illustrates this.

In the survey referred to (ref. 1), several pilots pointed out that providing a "window" (limitation 4) or a "floor" (limitation 3) gives pilots more latitude than requiring a crossing at a "hard" altitude (limitations 1 and 2) during the descent. It was also pointed out in the survey and in our reports that hard altitudes require constant adjustments of speed and/or power, and that they do not take account of variations in wind velocity at various altitudes. Other pilots, however, remarked that single or hard altitudes were easier to remember in a complex procedure.

TABLE 7.– ALTITUDE LIMITATIONS ON PROFILE DESCENT PLATES

| Altitude limitation | SFO OAK SJC | ATL | DEN | MIA |
|---|---|---|---|---|
| 1. "Cross (alt/flight level)" | 1 | | | |
| 2. "Cross at (x)" (see footnote) | 16 | 8 | 17 | 8 |
| 3. "Cross at or above (x)" | 20 | 4 | 4 | 3 |
| 4. "Cross at or above (x); Cross at or below (y)" | 3 | 8 | 16 | 2 |
| Number of plates examined | 15 | 8 | 16 | 8 |
| Average number of limitations per plate | 2.7 | 2.5 | 2.3 | 1.6 |

x = altitude/flight level.

The presentation of minimum enroute altitude (MEA) data on profile descent plates has been a matter of discussion since early in the profile descent program. The original Denver plates contained them; the original Atlanta plates did not. It has been pointed out that profile descents are published routes and that MEA information is therefore needed in the situation where a profile descent is cancelled in favor of a visual approach clearance; on the other hand, in most such situations pilots would deviate from the profile course after such a clearance was received. Regardless of the differences between the MEA and crossing restriction altitude depictions, which are now substantial, pilots continue to mistake one for the other on occasion:

> Upon crossing Keann intersection, while making Keann arrival for runway 17 at Denver, I looked at the arrival chart for next crossing restriction. My eye immediately picked up the 11,000 ft MEA which is shown on the chart between Keann and Bowen. I stated that this was the altitude we could descend to and my co-pilot verified the altitude. Prior to reaching 14,000 ft we discovered our error. The way the minimum enroute altitude and restriction are shown on the chart makes it very easy to confuse the two. I don't see any reason for the MEA's to be on the charts.

Chart complexity or "clutter" was identified as contributing to four errors in this study. The profile descent charts vary considerably in complexity, for several reasons. One is that in certain locations, the transition, arrival and profile descent procedures have been combined, whereas in other locations, the arrival and profile descent are separate procedures (albeit with almost the same names), require separate clearances, and are depicted on separate charts. The Miami charts, which incorporate transition data, are quite complex, though the profile descents to that airport are the simplest of those examined (table 8).

In July 1977, the NOS profile descent charts appeared in a new, oversize format which groups four profile descents leading to a single group of runways on a single chart. These charts represent an innovative approach to certain of the problems cited here, notably that of avoiding the use of data intended for use during approaches to the reciprocal runway. They are comparatively

TABLE 8.– SPECIFIC LIMITATIONS[a] WHICH MUST BE OBSERVED FOLLOWING INITIATION OF PROFILE DESCENTS

| Location | Procedures | Mean | Range |
|---|---|---|---|
| San Francisco | 6 | 7.7 | 6-9 |
| Oakland | 4 | 7.3 | 6-9 |
| Denver | 16 | 6.3 | 6-8 |
| Atlanta | 8 | 5.5 | 5-6 |
| San Jose | 5 | 5.2 | 4-6 |
| Miami | 8 | 4.8 | 4-6 |

[a]Heading, airspeed, or altitude limitations following initiation of the profile descent procedure.

uncluttered. They are used by relatively few professional pilots, however, and ASRS reports contain no comments regarding them. Certain of the Jeppesen profile descent charts for San Francisco occupy a full page; the presentation on these pages is also less cluttered than on some of the dual-procedure pages.

*Profile descent clearances*– As in previous studies of ASRS data (ref. 2), misunderstood clearances or clearance amendments were associated with errors during profile descents. Eight such cases were examined to determine, where possible, the content of the message that was misunderstood.

It was found that the most common misunderstanding was that pilots, having been told to expect the ABC profile descent and cleared for the ABC arrival, and in some cases given later instructions which corresponded to the initial profile descent instructions, believed that they were to continue the profile descent, when in fact they were not cleared to do so:

> . . . At a point just north of Rome VOR, on the 357 radial, a heading was assigned to this flight to intercept the Rome Six Arrival southeast of Rome VOR. In addition, the flight was told to "Expect a Rome-Runway 26 Profile Descent." The copilot was flying this leg and responded accordingly. While proceeding outbound from Rome VOR on the 132 radial, further instructions were given. The flight was to descend and cross the ATL VOR 9 DME fix on the 313 radial at 11,000 ft and 210 knots indicated (no clearance for the Rome 26 profile descent had been given even though the instructions followed the profile descent plate). As the flight approached the 9 DME fix with no further clearance, the captain asked what Approach Control's intentions were. They responded with instructions to turn to a 90° heading and descend to 5,000 ft. (Again, this followed the profile descent plate, but no actual clearance for this profile had been given.) During this stage of the descent, the flight was told to maintain 6,000 ft and given another heading. More headings followed during the descent. Finally, Approach Control questioned our altitude and I immediately noticed that the copilot had descended to approximately 5,600 ft (400 ft below the newly assigned altitude of 6,000 ft). He initiated a climb and regained the 400 ft . . . .
>
> Contributing factors: (1) The flight was told to expect a Rome-Runway 26 profile descent and was never given it; (2) Approach Control's instructions followed the published descent profile and then suddenly varied; and (3) cockpit distraction existed due to the variance of instructions between the flights as far as the profile descent was concerned and due to turbulence in the area. Also, we did not know what runway the vector was for since no runway profile descent had been assigned . . . .

A controller also spoke to this point in an informational report:

> The Big Sur STAR with runway 28 Profile Descent procedures appear to be confusing to many pilots as many flights are questioning or violating the procedure. The phraseology developed for profiles, "Cleared via Big Sur Arrival, expect runway 28/19 profile descent, maintain . . .," seems to adequately cover the requirements of ATC with the profile procedures although it has not been made mandatory nor is it published in handbook 7110.65. It appears that the pilots are not familiar with the PROCEDURAL NOTES contained in the P-2 FLIP and are often misinterpreting the phraseology being used.
>
> The phraseology and the procedure should be assimilated to insure a nationally standardized usage understood by pilots and controllers alike. The procedural notes in the P-2 must be reinforced with all pilots to insure rigid compliance, specifically the notes pertaining to ". . . a routing clearance and not authorization for the pilot to comply with depicted altitude . . ." and, "DO NOT DESCEND TO PROFILE DESCENT ALTITUDES UNTIL CLEARED BY ATC."

Another misunderstanding, more common during the early days of the program, was whether subsequent instructions do or do not void a profile descent clearance:

> We were cleared for a Lanier-runway 8 profile descent to Atlanta by Center . . . at 14,000 ft and 40 DME from ATL we reported to Approach Control at 14,000 ft and he replied "Roger, maintain 14,000." Over Loan intersection we started a descent to 11,000 ft. After reaching 11,000 ft I reported that fact to Approach Control and received "Do you intend to descend any lower?" I informed him that I was complying with the descent profile. He replied "You were cleared to maintain 14,000." I told him that I thought I was cleared for the profile descent and he replied "maintain 11,000." In retrospect, I now see that his statement "Maintain 14,000" voided the profile clearance even though he did not state the profile was cancelled . . . This appears to be a confusing trap for the pilots flying this type STAR.
>
> Aircraft A was cleared for the LaGrange 9R profile descent to Atlanta . . . The flight crossed the 40 DME fix at 14,000 and continued descending. Approach Control advised that aircraft A would be vectored for an ILS approach to runway 8. Aircraft A requested and was granted direct routing to the runway 8 LOM. The pilot in command of aircraft A contends that the clearance direct to the runway 8 LOM voids the runway 9L profile descent. Since implementation of the profile descents Approach Control has cancelled them whenever they have found it necessary to deviate even slightly from the published procedure . . . .

Late clearances or amendments pose a considerable problem for pilots constrained by the relatively inflexible limits of the profile descent procedure. Two reports illustrate the dilemma in which the pilot finds himself, particularly when a late amendment or other modification of the profile-procedure voids his planning and strategy:

I may have violated a FAR by crossing a profile descent point at the wrong altitude on a scheduled airline flight from DAB to ATL. ATL ATIS gave runways 8 and 9L in use. Approaching ATL I was cleared Sinca 8/9L profile descent and commenced the profile descent observing the altitudes. When nearing the ATL 25 DME fix, I was cleared for a 26/27L profile descent. Since I was to cross the D8/ATL fix at 11,000 ft with the previously cleared 8/9L profile descent I was placed in an untenable situation in that I was cleared for the 26/27L profile descent too late to comply with the D26/ATL altitude of 8000 ft and 210 knots. ATL Approach is prone to changing runways and approaches from those which one can expect from ATIS and previously indicated plans.

* * *

We were making a Sinca arrival into Atlanta from the Dublin VOR. Center had already cleared us to 18,000, then to 14,000. When we were approximately 60 miles from the ATL VOR and at about 20,000 ft, descending at 2500–3000 ft/min and 350 knots, Center cleared us for a Sinca profile descent to runway 26/27L. After giving this clearance, the Center added "Cross the 40 DME at 250 knots." The profile descent requires crossing the 45 DME at or above 14,000 ft with no airspeed restriction, then crossing the 25 DME at 8000 ft and 210 knots.

We were unable to slow down and cross the 25 DME at 8000. Center was aware of our crossing the fix at about 8800 ft as they said "See you did not make the crossing altitude, but that's ok, contact Approach Control." Several factors contributed to our inability to make the crossing altitude:

1. The current wide-body aircraft cannot slow down and descend with any degree of rapidity at the same time. Even with the use of full in-flight spoilers, it requires a great deal of distance.

2. At any of these flap settings and limiting speeds, the best rate of descent is about 2000 ft/min.

3. ATC personnel are not familiar with the performance limitations of the various aircraft.

4. Profile descent altitudes and airspeeds require almost the maximum performance capability of the aircraft and leave little margin.

5. The profile clearance in this case was late in delivery and the speed restriction, delivered even later, made compliance impossible . . . .

If ATC procedures are going to continue to require high descent rates while decreasing air speed, this should be considered when designing flaps and other drag devices and their operating speed limits . . . .

Pilot comments make it plain that they are quite comfortable about flying profile descents as charted (although the apeed restrictions at high altitudes at Denver provoked several unfavorable

comments in view of the stated purposes of the program). Pilots also point out, however, that subsequent additions to the already complex profile descent procedural constraints, in the form of additional headings, altitude or speed restrictions, make a demanding task very much more demanding and divert the attention of all cockpit crew from the other tasks which must also be accomplished during the descent and approach phases of flight:

> During the execution of the Kiowa runway 26 profile descent, constant and mostly uninterrupted ATC controller radar vectoring was encountered by this flight and an estimated six other IFR aircraft approaching the airport. The excessive vectors, altitude changes, and airspeed reductions (other than those published) required by the profile descent method of enroute-approach transition unnecessarily complicate the cockpit workload during this critical phase of flight prior to ILS/glidepath intercept. Checklists must be completed. Approach speeds must be computed and the instrument approach navaids must be identified during this phase of flight. Unnecessarily frequent radio transmissions during the terminal descent are undeniably distracting . . . and therefore degrade aviation safety . . . .

*Profile descent rules and procedures*— A perceptive informational report to ASRS encapsulates effectively many of the concerns in pilots' and controllers' reports to ASRS concerning profile descent rules and procedures. It should be recalled that there are air carrier pilots who in the course of a single trip may conduct profile descents at as many as four terminals, each of them having procedures and charts somewhat different from all of the others:

> . . . Most of all, I feel that inconsistencies from one terminal to another terminal result in procedures that are difficult for even the most experienced airline and corporate pilots – even though any one . . . person believes his profile descent is better than those found at another location, we believe all profile descents should be almost the same. It is (in) that spirit that we highlight many differences in this (report). Additionally, we wish to point out some discrepancies observed by many pilots who have flown profile descents.
>
> > . . . Reference SFO runway 19 PD (Big Sur): The note "Descend at 330 knots from FL230 until required to reduce to 250 knots" appears only at SFO and no other terminal.
> >
> > . . . Reference SFO runway 29 PD (Modesto): There is no computer code for the STAR portion of the profile descent. The STAR route from Modesto is actually MOD4 although (this is) not stated . . . Persons arriving by INS . . . direct to MOD then via the PD have no way of filing for this route . . . .
> >
> > . . . Reference SFO runway 28 PD (Big Sur): Same situation . . . prompted one pilot not to accecp Big Sur arrival because it was labeled Profile Descent and not the Big Sur Arrival.
> >
> > . . . Reference DEN Keann One Arrival, DEN runways 8L and 8R Keann Profile Descent, OAK runway 29 Profile Descent (Modesto): By comparison, it can be seen that STARs are in effect at Denver and are to be used

prior to (referring to) the appropriate Profile Descent. All ... STAR transitions are part of the STAR ... Looking at ... Oakland ... all transitions, STAR and profile descent are all on one page. Even though more apparent clutter is on the single page, the pilot needs to (use) only one page ... all the way to the instrument approach ....

... Some profile descents start as low as 10,000 ft while others start at FL250. In either case, pilots have asked "Why?" Also, pilots don't necessarily know when and where to begin their descents out of cruising altitudes ....

... (At Denver) a speed restriction of 250 knots is required 57 miles from the threshold ... at an altitude as high as FL230. Most other PDs don't require the 250-knot restriction until 10,000 ft ....

... (At Miami) The Falso runways 9L and (R PD's have their) first speed and altitude restriction ... only a short distance from the runway. Most others start at the first PD fix.

... The first altitude restriction on some PDs states "Cross at ...," others state "Cross at or above ...," while others use a window ... Why so many differences? (Note: see table 7.)

... There have been so many changes to the rules for profile descents that (we got a) new bulletin ... for each new cycle ....

... Reference DEN runways 26L and 26R Keann PD: The radar vector route from Burty intersection proceeds south and then turns inbound on the 26L localizer. This has been interpreted by pilots to mean that they should turn inbound when their navigational instruments show them (approaching) centerline (rather than awaiting further vectors) ... some pilots and some controllers disagree on what (is correct) ....

... Reference SFO runway 28 PD (Modesto and Point Reyes): For a while, PD's were called "STAR with Profile Descent procedure" but are now being changed to "Profile descent procedures ....

... Reference DEN Drako One Arrival and SFO runway 28 PD (Modesto): Since the Denver and Atlanta STARs are separate, many items of text appear on the pages, whereas at SFO, the STARs have no narrative route descriptions ....

... Reference SFO runway 28 PD (Modesto): Although it is not readily apparent, the PD begins at Modesto for traffic arriving on the Fresno transition. The PD begins at the MOD R-064/11 DME for traffic ... from the other transitions ....

It seems to us that in order to achieve standardization for . . . profile descent procedures, and to achieve a common understanding by controllers and pilots as to what is expected of them, certain actions must be taken . . . for standardization purposes, an Agency Order/Handbook (should) be developed so that runway profile descents will be similar at all locations . . . (as has been done for SIAPs) . . . .

Some sort of a document needs to be prepared with input from all affected organizations that can provide the necessary educational material on runway profile descents for pilots, controllers, and operators. This is not something that should be prepared on a "crash" basis; (it) should be thoroughly developed and agreed to, so that amendments . . . would be required only at very infrequent intervals . . . .

. . . We certainly agree with the profile descent concept, but feel it has gotten off to a poor start . . . .

Four informational reports related to possible conflicts between arriving and departing traffic. One concerned Denver and was reported to FAA shortly after the program began in December, 1976. The other three all involved the Atlanta Sinca profile descent; extracts from them are shown:

ATC cleared flight for Sinca profile runway 26/27L descent. This has a 25 DME fix, crossing altitude of 8000 ft. Approximately 3 miles from the fix, Approach Control advised "You should be at 8000 ft now; we cross aircraft there at 9000 ft." If this is true it appears his map and DME position do not agree. At any rate, we were out of 9300 ft descending when he said this. We cross the intersection at 8000 ft. These are very close tolerances; too close, considering the aircraft speeds.

* * *

The profile descent procedure . . . from the south (from over Dublin) allows the aircraft to enter Macon Approach Control's airspace . . . .

* * *

It appears that crossing restrictions on the Sinca profile descent may not provide separation from departures from Atlanta. Our procedures leave doubt as to who is responsible if pilots do not or cannot make restrictions . . . .

*Aircraft operational problems*— One controller report pointed out that certain profile descents, especially if initiated late, may require high rates of descent, and that when descent rates exceed about 4600 ft/min, the controller is deprived of altitude information:

. . . The other RDP related problem is the altitude readout going to XXX during a climb or descent. Data Systems says that the problem is caused because the altitude logic check is set nationally at about 4600 ft per minute . . . Any time an aircraft exceeds the parameter, the computer will assume that there is an error and will not display the altitude. The problem here is that with the high profile descents being instituted across the country, there will be more altitudes going to XXX as

more pilots participate in the program. If this becomes the rule rather than the exception, then the altitude readout function (will) lose a lot of its usefulness . . . .

Several pilot reports indicated that clearances can exceed aircraft capabilities. This appears to be a particular problem with one type of aircraft, but several pilots anticipated problems during the coming winter, when higher power settings will be required to maintain aircraft and nacelle de-icing.

> . . . This profile descent is just a little tight to make, as you cross 45 DME fix at 14,000 ft and the 25 DME fix at 8000 ft and 210 knots. With . . . a tailwind, this will be even tighter . . . .
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> * * *
>
> . . . Current wide-body aircraft cannot slow down and descend with any degree of rapidity at the same time. Even with the use of full in-flight spoilers, it requires a great deal of distance . . . .
>
> * * *
>
> . . . When crossing the 45 DME/ATL 128 radial at or above 14,000 ft as required on the Sinca runways 26/27L profile descent, you cannot make the 25 DME at 8000 ft and 210 kias using normal descent procedures. My aircraft descends at approximately 1000 ft/3 miles at idle power, clean; 14,000 minus 8000 equals 6000 ft times 3 equals 18 miles just to descend. At normal descent speed of 350 kias, it takes 7 miles to show to 250 knots at 10,000 ft (airspeed at 25 DME is to be 210 knots).
>
> The only way to make these crossing restrictions is to be way below normal descent speed at the 45 DME fix, reverse the inboard engines . . . or slow to flap speed at 14,000 (220 knots for 0–15 flaps) and descend with flaps down . . . .

*Human factors in profile descents–* The preceding discussion has dealt primarily with system problems as they affect the pilot during profile descents. This section is devoted to a brief consideration of what those effects are, and of how they are viewed by pilots and controllers.

Two human factors were often cited in these reports: workload and distraction. The profile descent is a relatively demanding, time-paced task consisting of from four to nine specific control subtasks (table 8) during a period of 5–10 min. To this fairly complex tracking task is added the tasks of completing the approach/descent checklist, any communications that are required, the resetting of navigational radios, and any other subsystem operations necessary during this phase of flight. All of these tasks, except communications, require visual as well as intellectual attention, as does the very necessary task of maintaining a lookout for other aircraft in visual meteorological conditions:

> Received clearance for a profile descent into Denver. Informed Center unable to comply with clearance because we could not make the first crossing restriction. We were told to make a left 360° turn. While in the turn, Center gave me the profile descent clearance again. I told them I didn't want to accept it. They said "If you

> don't like it, call this phone number after you land" . . . We were so busy reading the profile descent plate that we could not look out the windows at all during VFR conditions. Center would not give us a verbal clearance so we could fly the airplane with our eyes and use our ears to get the instructions . . . we must use our eyes to understand the clearance at the same time we use our eyes to fly the airplane . . . .

Most profile descents as presently configured require the almost undivided attention of one pilot, and a considerable amount of monitoring by a second crew member. It appears that under these conditions, it is the outside lookout that suffers most:

> . . . The Denver profile descents have so many altitude and speed restrictions over so many points that the major attention of the crew is directed at checking the crossing points and altitudes and speeds . . . too little time is spent watching for other aircraft, thus increasing the hazard of midair collisions beyond acceptable limits . . . .

To these tasks may be added the additional task of complying with vectors or additional speed restrictions or altitude restrictions. Under these conditions, cockpit workload may exceed for a time the flight crew's ability to stay ahead of the situation:

> My comments are on descent profiles . . . I find that (they) are not working the way they were supposed to work . . . these profiles impose a greater workload on the pilots, expecially in a two-man crew . . . Another point is that there are so many for each airport that they distract us from cockpit duties, especially in bad weather . . . From my point of view, the descent profiles may ease the controller's workload, but it makes aircraft workloads much higher. In the descent, most of the time at peak hours, they break down with vectoring back and forth to the profile, and it can get messy . . . I have never done a profile descent (as written) to completion, out of probably 15 . . . .

It is believed that such periods of overload may be a major factor in the instances reported here of misreading of charts or cockpit instruments, glances at incorrect charts, etc. When unfamiliarity or training is an added factor, as in six cases, still another element is added to the crew's workload:

> . . . I was pilot in command . . . with additional duty of conducting initial operating experience training for the first officer . . . this was his first flight in this capacity. The flight was routine . . . arriving in the Atlanta area we encountered some large buildups in the vicinity of Macey intersection, requiring deviation east of course. Following hand-off to Approach Control, and after crossing the ATL 041 radial 40 DME fix, a runway 8/9R profile descent was initiated as clared. I flew the aircraft with first officer assisting. The ATL 20 DME fix was crossed at 11,000/250 kias; shortly after crossing this fix I began reducing speed to arrive at the 9 DME fix at 210 knots. At this point I made a severe error by misinterpreting the procedure, started descent too early and crossed the 9 DME fix too low . . . Air traffic was fairly heavy with frequent radio contacts; calls were replied to by first officer and myself when first officer was unable due to cockpit duties . . . .

Finally, environmental or aircraft system problems beyond the control of the pilot may increase workload further. A strong tailwind decreases the time available for the task and requires that the aircraft be flown closer to its prescribed descent limits. Turbulence increases the difficulty of the tracking task. Thunderstorms near the route of flight require the pilot to operate and monitor radar in addition to his other tasks. Aircraft subsystem problems can be a potent distracting factor:

> Scattered to broken thunderstorms east of Denver with bases at 8,000–10,000 ft; approaching Denver from J80 direct Kiowa, Kiowa One arrival. Cleared for Kiowa runway 26 profile descent. Our crew purposely studied Denver profile descents the night before the flight as we had not executed the full ... procedures before. We reviewed the charts once again during cruise. We executed the profile descent without any problems except having to ride through bases of thunderstorms intermittently.
>
> Our main concern ... is that it took complete attention inside the cockpit to cross-check the altitude crossing restrictions ... speed restrictions, not including possible speed adjustments for turbulence ... The chart as flown is a very rapid exercise in heading, course, altitude, and speed changes requiring continuous cross-checking ... Pilot not flying spends his entire time changing radios (navaids and communications). The second officer is cross-checking both pilots plus reading checklists and performing his normal duties. We found that none of us had time to scan outside the cockpit enough to see any conflicting traffic. We feel that these profile descents ... have increased the cockpit workload during the flight phase when it should be decreased ... add weather and/or an emergency and you have an accident waiting to happen ....
>
> * * *
>
> We were at an improper altitude over two fixes during a profile descent. Problem was discovered when I realized that I was looking at descent information for east landing profile instead of west. Action taken was to increase descent rate abruptly to get to proper altitude. No evasive action was necessary. The factors that contributed to the situation were that both profiles are on the same side of the page. The first officer was assisting the second officer with a pressurization problem and it was my seventh day on duty in a row ... you cannot know your failing point until you fail ....

It is worth noting that workload and distraction factors were cited in several controller reports as well. This is not a problem only for the pilot:

> Controller and trainee were working final approach and the new profile descent was being utilized. Airline A was on downwind descending to 5000 ft. Light aircraft B was northbound and level at 6000 ft. B was issued clearance to 4000. At this time the controller's and trainee's attention was with other aircraft near the airport. An effort was being made to "shoot the gap" with a small aircraft (VFR). The instructor had planned to use south runways for landing after coordination with tower. The trainee did not understand this and questioned the decision. Tower also

talking to us on the override. At that point I saw aircraft A leaving 6200 on a converging course with B who was leaving 5800. Aircraft A was issued a turn for separation; they were two miles apart and the turn was too late . . . profile descents allow aircraft to enter congested areas with too much speed . . . .

* * *

At 2129Z I relieved controller on sector 15 interphone and radar. He briefed me on . . . aircraft A landing Stapleton . . . and aircraft B, a Denver departure climbing to FL220 deviating around thunderstorms . . . in the arrival and departure gates . . . After working with some other traffic in the southeast part of the sector . . . I observed A and B to be head-on . . . I believe I never had less than standard separation. After listening to the voice recording, I determined why A did not stop at FL230. The controller I relieved did clear A to FL230 after an earlier clearance for a profile descent; however, when the controller released his microphone switch after giving the amended clearance, the pilot of A was also on the frequency in the middle of a sentence . . . the pilot never heard the amended clearance and so an acknowledgment was never received by the controller . . . .

These are all factors that confront professional pilots and controllers on a daily basis. They are proud of their ability to cope with whatever confronts them. It should be noted, however, that the final approach phase of flight, a very high workload period under difficult conditions, has received much attention with regard to presenting as few distractions and additional tasks as possible. All air carriers insist that the final phase of the approach be stabilized, in part for the same reason.

Certain profile descents demand the same order of precision as the final approach, but pilots may be subjected to far more in the way of distracting stimuli during this phase of flight. If cockpit workload during the descent is increased by profile descent procedures, and there is abundant evidence that it is, then ways must be found to ensure that this workload is not further increased by more than the necessary minimum of other system, communication, and ancillary tasks, or further navigational tasks or procedures.

## General Discussion

It is necessary to recall that a great many profile descents are being flown without incident on a daily basis. Their successful accomplishment is rarely reported to ASRS. The problems discussed in this report may not be representative, although they are in close accord with the findings of others and with the comments of highly experienced air carrier observers with whom the profile descent program has been discussed. Finally, the reports on which this study is based, like all ASRS data, represent only the perceptions of the reporters, unsupported by independent investigation. On the other hand, these perceptions appear to have a high degree of consistency, just as do the errors that occur during profile descents.

It is understood that steps are being taken to correct certain of the problems described here. This report covers only the period through October 6, 1977. It is hoped that it may be of assistance to those responsible for the program by pointing out some of the human factors aspects of the

program as initially implemented, and of help to the pilots and controllers involved in the program by helping them to be aware of pitfalls that may contribute to human errors during the conduct of profile descents.

## References


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